R E P O R T R E S U M E S

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AUTOMOTIVE DIESEL MAINTENANCE 1. UNIT XXII, I--MAINTAINING THE FUEL SYSTEM (PART I)--CUMMINS DIESEL ENGINE, II--UNDERSTANDING THE DIFFERENTIAL.

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THIS MODULE OF A 30-MODULE COURSE IS DESIGNED TO DEVELOP AN UNDERSTANDING OF THE FUNCTION AND MAINTENANCE OF THE DIESEL ENGINE FUEL SYSTEM AND DIFFERENTIAL DRIVE UNITS USED IN DIESEL POWERED VEHICLES. TOPICS ARE (1) FUEL SYSTEM COMPARISONS, (2) FUEL SYSTEM SUPPLY COMPONENTS, (3) FUEL SUPPLY SECTION MAINTENANCE, (4) FUNCTION OF THE DIFFERENTIAL, (5) CONSTRUCTION OF THE DIFFERENTIAL, AND (6) DIFFERENTIAL REMOVAL. THE MODULE CONSISTS OF A SELF-INSTRUCTIONAL BRANCH PROGRAMED TRAINING FILM "UNDERSTANDING THE CATERPILLAR FUEL SYSTEM" AND OTHER MATERIALS. SEE VT 005 655 FOR FURTHER INFORMATION. MODULES IN THIS SERIES ARE AVAILABLE AS VT 005 655 - VT 005 684. MODULES FOR "AUTOMOTIVE DIESEL MAINTENANCE 2" ARE AVAILABLE AS VT 005 685 - VT 005 709. THE 2-YEAR PROGRAM OUTLINE FOR "AUTOMOTIVE DIESEL MAINTENANCE 1 AND 2" IS AVAILABLE AS VT 006 006. THE TEXT MATERIAL, TRANSPARENCIES, PROGRAM TRAINING FILM, AND THE ELECTRONIC TUTOR MAY BE RENTED (FOR $1.75 PER WEEK) OR PURCHASED FROM THE HUMAN ENGINEERING INSTITUTE, HEADQUARTERS AND DEVELOPMENT CENTER, 2341 CARNEGIE AVENUE, CLEVELAND, OHIO 44115. (HC)

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STUDY AND READING MATERIALS

AUTOMOTIVE DIESEL MAINTENANCE 1

I - MAINTAINING THE FUEL SYSTEM(PART I) -- CUMMINS DIESEL ENGINE

II - UNDERSTANDING THE DIFFERENTIAL, UNIT XXII

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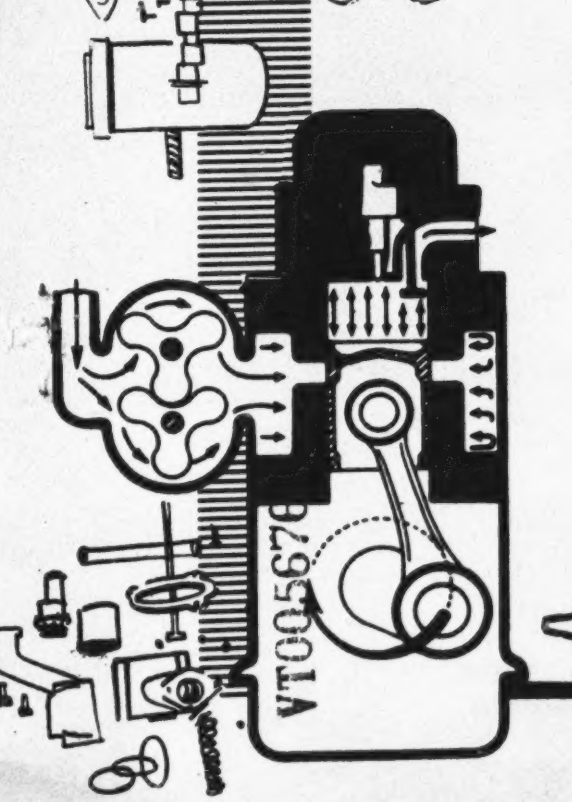
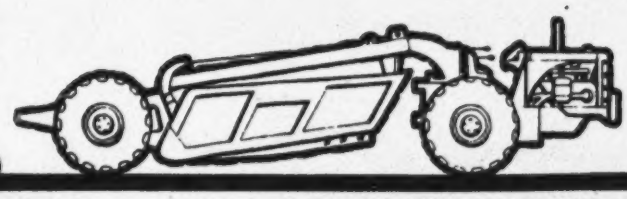




This unit is presented in two parts. The first part covers the first in a series of discussions about the caterpillar engine fuel system. The second part will cover briefly what a differential is and its purpose on a vehicle.

I -- MAINTAINING THE FUEL SYSTEM (PART I) -- CATERPILLAR DIESEL ENGINE

SECTION A -- FUEL SYSTEM COMPARISONS

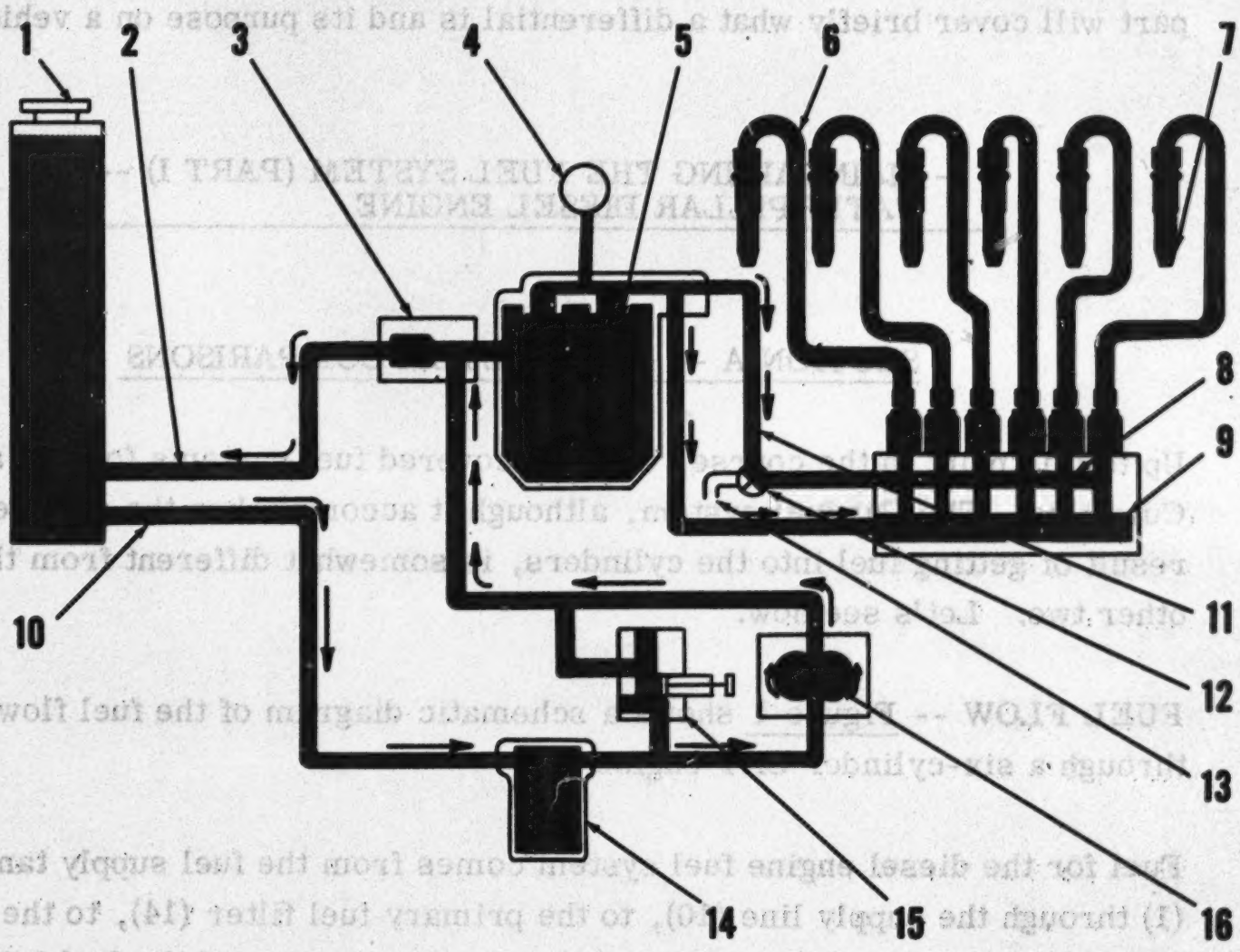
Up to this point in the course, we have covered fuel systems for GM and Cummins. The Cat fuel system, although it accomplishes the same end result of getting fuel into the cylinders, is somewhat different from the other two. Let's see how.

FUEL FLOW -- Figure 1 shows a schematic diagram of the fuel flow through a six-cylinder CAT engine.

Fuel for the diesel engine fuel system comes from the fuel supply tank (1) through the supply line (10), to the primary fuel filter (14), to the fuel transfer pump (16), which is located on the bottom of the fuel injection pump housing.

The fuel transfer pump (16) forces fuel through the fuel injection pump housing adapter and fuel filter housing cover to the fuel filters (5). A spring-loaded bypass valve (3), located in the housing adapter, maintains approximately 25 pounds fuel pressure in the fuel filter housing and fuel injection pump housing. Excess fuel supplied by the pump is bypassed through the return line (2) to the supply tank (1).

After passing through the fuel filters, the fuel flows through passages in the filter housing cover and adapter to the fuel manifold (9) which distributes fuel to the fuel injection pumps.



FLOW OF FUEL (SCHEMATIC)

1–Supply tank.
2–Return line.
3–Bypass valve.
4–Pressure gauge.
5–Fuel filter.
6–Fuel injection line.
7–Fuel injection nozzle.
8–Air bleed manifold.
9–Fuel manifold.
10–Supply line.
11–Air bleed passage.
12–Air vent valve.
13–Vent line.
14–Primary filter.
15–Priming pump.
16–Transfer pump.

Fig. 1 Flow of fuel through a six cylinder CAT.

A cam-actuated injection pump for each cylinder forces fuel through an injection line (6) to the proper injection nozzle (7). A definite quanity of fuel is forced into the precombustion chamber by the injection pump at the proper time, and starts to burn.

One air vent valve (12) is provided to vent the air from the entire fuel system. It is located on the adapter between the filters and the injection pump housing. When the vent valve is opened and fuel is caused to flow by action of either the transfer pump or a priming pump, air escapes through the vent line (13). An air bleed passage (11) allows air to escape from the top of the fuel filter housing cover, and the air bleed manifold (8) allows air to escape from the injection pump housing.

When the fuel system is vented, the bleed valve should be left open until a solid stream of fuel flows out the drain tube, indicating that all air has been bled from the system.

The fuel pressure gauge (4) is connected to the top of the fuel filter housing cover. Lack of pressure on the guage indicates difficulty in the supply side of the system. This could be caused by an empty diesel fuel tank, a closed shutoff valve at the tank, clogged filters, dirt under the bypass valve, open vent valve, a faulty transfer pump or gauge.

To eliminate the possibility of a clogged filter causing a low fuel pressure gauge reading, install new filter elements.

Air in the system or water in the fuel can also be responsible for the engine firing irregularly or failing to start.

If, after eliminating the above possibilities, there still seems to be something wrong with the fuel system, check the injection side of the system. Fuel injection pumps and fuel injection valves can be checked as described later.

Many times the fuel system is blamed when the fault lies elsewhere. A smoky exhaust may be caused by faulty fuel injection valves, but it can also be caused by a dirty air cleaner, overloading at high altitude, badly worn piston rings, or an improperly operating or incorrectly adjusted rack limiter. Generally, check for the simplest thing first, which would be the air cleaners.

Irregular firing can be caused by faulty fuel injection valves. It can also be caused by the burning of excessive lubricating oil which gets past worn piston rings, or new rings which have not become fully seated.

SECTION B -- FUEL SYSTEM SUPPLY COMPONENTS

FUEL TRANSFER PUMP -- The conventional positive displacement type gear pump is mounted on the fuel injection pump housing and is driven by a gear on the rear of the fuel injection pump camshaft.

This pump has ample capacity to supply more fuel than is required for engine operation at any load. Reserve capacity insures adequate delivery of low pressure fuel under any operating conditions for a very long period. The life of the pump is determined by the cleanliness of the fuel it handles.

BYPASS VALVE -- A spring-loaded, non-adjustable, bypass valve limits the pressure within the fuel supply system. The valve maintains approximately 15 to 25 pounds pressure on the fuel in the lower chamber of the filter housing. Excess fuel is bypassed back to the inlet side of the transfer pump, or on some models it returns to the fuel tank, see Figure 1.

On track type tractor engines, the bypass valve is located in an adapter attached to the transfer pump housing.

On wheel tractors, track type tractors with torque converters, industrial

and marine engines, the bypass valve is located near the top of the fuel filter housing.

DIRT PREVENTION -- Before getting to the main fuel filters, the CAT engine has two components to guard against dirt getting into the system. One is a filler cap which allows the tank to breathe and filters out dust and dirt at the same time. The second is a strainer located in the filler neck of the tank. This strainer prevents dirt particles from entering with the fuel when the tank is being filled.

To ensure that the cleanest possible fuel is drawn from the tank, the suction end of the supply line is raised to provide space at the bottom of the tank for moisture and dirt to settle out. Any accumulations of moisture and sediment should be periodically removed from the tank through the drain valve. NOTE: Filling the fuel tank at the end of each work period helps prevent condensation from accumulating in the fuel tank by driving out the moisture laden air.

MAIN FUEL FILTERS -- From the fuel transfer pump, fuel flows to the filter housing which is divided into two compartments -- an unfiltered side or lower chamber and a filtered side or upper chamber. Separating the two chambers are the retainer plate and the fuel filter elements.

Fuel enters the filter housing through an inlet tube which discharges incoming fuel high in the unfiltered chamber of the housing. This leaves the lower part of the chamber relatively undisturbed so that larger foreign particles have an opportunity to settle out rather than clog the filter elements. After the fuel flows through the filter, it enters the upper chamber of the filter housing.

TYPES OF FILTERS -- Filter elements may be either the absorbent cotton wound or plastic impregnated paper type, depending on the engine model. In either case, the filtering process is the same: the flow of fuel is from the outside to the inside of the filter element.

The outer section of absorbent cotton wound elements will collect and hold particles until fuel will no longer flow through them at a rate to maintain maximum engine performance. A fine grade filter paper wrapped around the center core prevents the filters from discharging their burden into the clean fuel.

The paper type element, like the absorbent cotton element, filters the fuel twice. Initial filtering is accomplished by use of plastic impregnated paper, pleat-folded around a perforated metal core. Final filtration is accomplished by a fine grade filter paper wrapped around the metal core. The element will continue to collect dirt particles until fuel will no longer flow through it at a rate to maintain maximum engine performance.

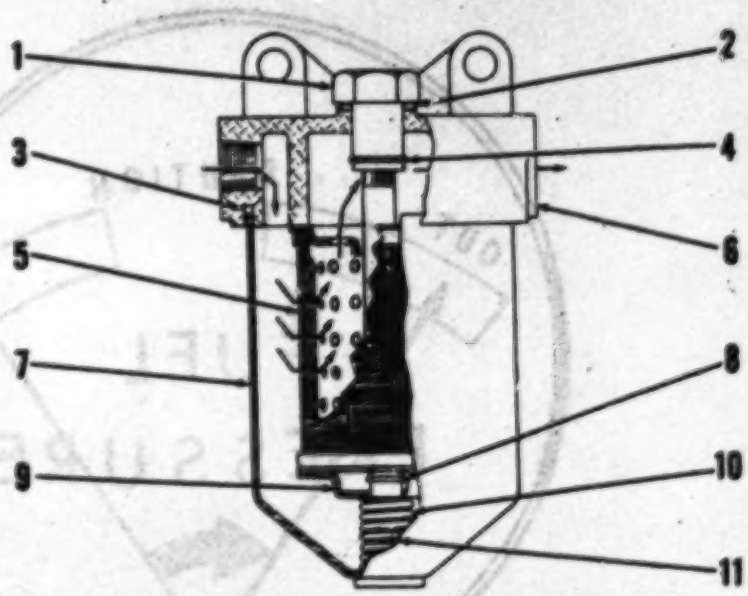
PRIMARY FUEL FILTER -- In addition to the dirt prevention characteristics of the fuel tank mentioned above, many systems have a primary filter element located in the fuel supply line between the tank and the transfer pump. It is mounted on the governor housing just below the governor control linkage. Figure 2 shows a primary fuel filter; let's trace the flow of fuel through it.

Fuel from the tank enters the filter assembly and passes through a washable metallic element (5) and into the transfer pumps. Any abrasive material or sediment (11) is removed by filter element and settles to the bottom of the case assembly (7).

VENT VALVE -- Air trapped in the main filter housing when elements have been changed or when the fuel system has been completely drained, can be removed through the vent valves located in both the filtered and unfiltered compart ments of the housing.

PRIMING PUMP -- In Figure 1 (15), a hand operated priming pump is located between the primary filter and the transfer pump, with a connection downstream of the transfer pump and main filters. This pump makes the engine easier to start when the filters have been changed or the fuel

system has been drained. Without it, excessive engine cranking is required while waiting for the system to be filled with fuel. NOTE: Most CAT diesels are equipped with gasoline starting engines.



1-Nut. 2-Gasket. 3-Gasket. 4-Ring. 5-Element. 6-Cover. 7-Case assembly. 8-Ring. 9-Retainer. 10-Spring. 11-Sediment.

Fig. 2 Primary fuel filter.

FUEL PRESSURE GAUGE -- Figure 3 shows a fuel pressure gauge which is located on the filtered side of the filter housing. This gauge shows an indication only when the engine is running. Lack of pressure on the gauge indicates difficulty somewhere in the supply supply system. This gauge could be thought of as a fuel filter condition gauge, since lower pressure usually indicates clogged filters.

As the filter elements gradually become plugged, the indicator on the fuel gauge will slowly drop back from the "NORMAL", or white range, to the "CAUTION", or green range, and finally to the "OUT", or red range. When the indicator reaches the "OUT" range, it is an indication that the filter elements are restricting the flow of fuel and the elements should be replaced immediately.

Keep in mind that gradual dropping back of the needle as the engine is operating indicates clogged filters, but if a sudden drop is noticed, the cause will more than likely be a stuck or faulty bypass valve, open vent valve, inoperative fuel transfer pump, empty fuel tank, or restriction in the line from the fuel tank to the transfer pump.

FUEL MANIFOLD -- From the filtered side of the filter housing, fuel flows to the manifold in the fuel injection pump housing. At this point, the fuel leaves the supply section and enters the injection section of the system. Before moving on to the injection section of the fuel system, let's review some maintenance practices that are necessary for the supply section.

Fig. 3 Fuel pressure gauge.

SECTION C -- FUEL SUPPLY SECTION MAINTENANCE

First, the fuel tank filler cap -- care of the cap is often overlooked or neglected during routine maintenance on a machine. For complete protection against dust and dirt entering the supply tank through the filler cap, the elements in the cap should be cleaned every 50 to 250 service hours, depending upon the amount of dust in the air.

Next, the strainer in the fuel tank filler neck -- periodically remove, clean and inspect the strainer when an accumulation of sediment is noticed or when the screen becomes clogged and restricts the entry of fuel when filling the tank. If it is cut or damaged by the hose nozzle, replace the screen but never refuel without it!

The drain valve at the bottom of the tank should be opened every 125 service hours to allow accumulated sediment and moisture to drain from the tank. Sure, you'll lose a small quantity of fuel, but that loss is better than running with water and dirt in the tank.

What about scheduled maintenance on the filter housing? There are just three important rules to remember. First, every 50 service hours drain the filter housing to remove accumulations of sediment and moisture. Before installing new filter elements, always drain and flush the filter housing.

Second, never open the fuel filter housing unless fuel filter elements are to be changed. Nothing is gained by checking the appearance of the elements --the fuel pressure gauge is the best indicator of element condition. Opening the filter housing for a visual check could introduce dirt into the fuel filter housing.

Third, always clean the filter housing cover and around the edges of the gasket joint before it is removed to install new filter elements. This prevents dirt dropping into the filter housing when the cover is removed.

PART II -- UNDERSTANDING THE DIFFERENTIAL

SECTION A -- FUNCTION OF THE DIFFERENTIAL

If a vehicle were always driven in a straight line, without having to turn a corner, the differential would not be required. However, when a vehicle turns a corner, the outer wheel must travel farther than the inner wheel travels (it covers part of a larger circle). For instance, if a right angle turn is made with the inner wheel turning on a 20 foot radius, this wheel travels about 31 feet; see Figure 4. The outer wheel, being nearly 5 feet from the inner wheel, turns on a 24 2/3 foot radius and travels nearly 39 feet.

If the propeller shaft were geared rigidly to both rear wheels, so that they would both have to rotate together, then each wheel would have to

skid an average of four feet in making the turn shown in Figure 4. In addition the vehicle would be very difficult to control around turns. The differential eliminates these troubles because it allows the wheels to rotate through a different number of turns when the vehicle makes a right or left turn.

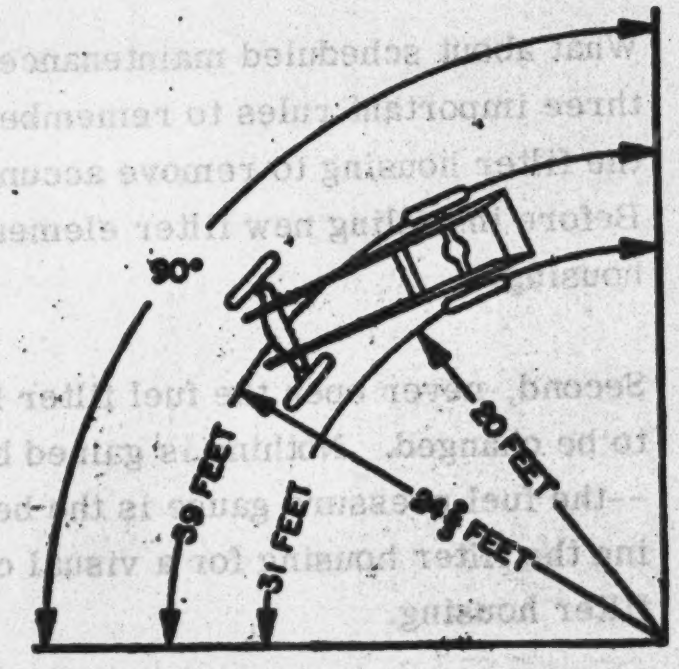


Fig. 4 Difference in wheel travel.

SECTION B -- CONSTRUCTION OF THE DIFFERENTIAL

To study the construction and action of the differential, let us build up, in effect, a simple one; see Figure 5. The two rear wheels are attached, through the axles, to two small bevel side gears; see Figure 5 (a). There is a differential case assembled around the left axle; see Figure 5 (b). The case has a bearing that permits it to turn independently on the left axle. Inside the case is a shaft that supports a third bevel gear; see Figure 5 (c). This third bevel gear, called the differential-pinion gear, is meshed with the two axle bevel side gears. When the differential case is rotated, both axle bevel gears rotate and both wheels turn. However, let us suppose that one wheel is held stationary. Then, when the differential case is rotated, the differential pinion gear will also rotate as it runs around on the stationary axle bevel gear. As it rotates in this manner, it carries rotary motion to the other axle bevel gear, causing it and the wheel to rotate. It can be seen that when one rear wheel turns more rapidly than the other, the differential pinion gear spins on its shaft, transmitting more rotary motion to one rear wheel than to the other. When both wheels turn at the same speed, the differential-pinion gear does not rotate on its shaft.

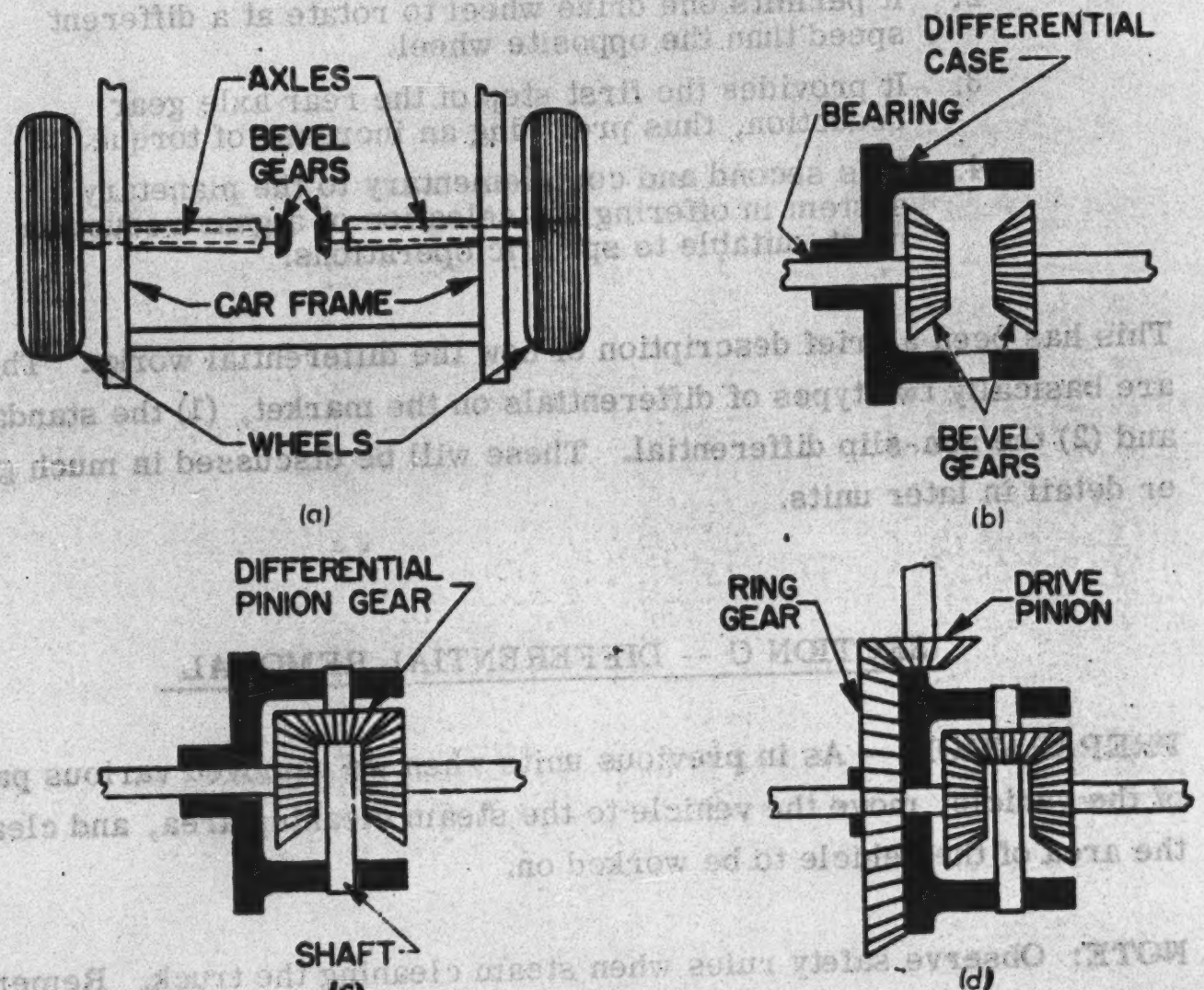


Fig. 5 Rear axle and differential

The differential case is rotated by means of a ring gear attached to it. This ring gear is meshed with a drive pinion on the end of the propeller shaft, see Figure 5 (d). When the vehicle is on a straight road, the ring gear, differential case, differential pinion gear, and two axle bevel gears all turn as a unit, without any relative motion. However, when the vehicle begins to round a curve, the differential-pinion gear rotates on its shaft to permit the outer rear wheel to turn more rapidly than the inner rear wheel.

We can say then that the differential of any vehicle serves four basic functions:

1. It transmits the torque from the driveline to the axle shafts.

2. It permits one drive wheel to rotate at a different speed than the opposite wheel.
3. It provides the first step of the rear axle gear reduction, thus providing an increase of torque.
4. It is second and complementary to the planetary system in offering the selection of a gear reduction most suitable to specific operations.

This has been a brief description of how the differential works. There are basically two types of differentials on the market, (1) the standard and (2) the non-slip differential. These will be discussed in much greater detail in later units.

SECTION C -- DIFFERENTIAL REMOVAL

PREPARATION -- As in previous units when we removed various parts of the vehicle, move the vehicle to the steam cleaning area, and clean the area of the vehicle to be worked on.

NOTE: Observe safety rules when steam cleaning the truck. Remember, the time spent in doing a good job of cleaning will be made up on actual maintenance time.

Next, move the vehicle to the work area and be sure it is well blocked to prevent rolling when the brakes are released.

REMOVAL -- If the differential is to be removed, it is not necessary to jack up the wheels or to remove the driving flanges or planetary gearing.

Units equipped with 4RA rear axle have the planetary gearing inboard and require removal of both inner and outer axle shafts. The caps and outer axle shafts have to be removed (see Figure 6) to permit accessibility to the inner shafts, the ends of which are engaged with the differential side gears. With a tool similar to the threaded rod, shown in Figure 7,

inserted into the threaded hole of the inner axle shaft, withdraw the inner shaft far enough to grasp the end. Remove the threaded rod.

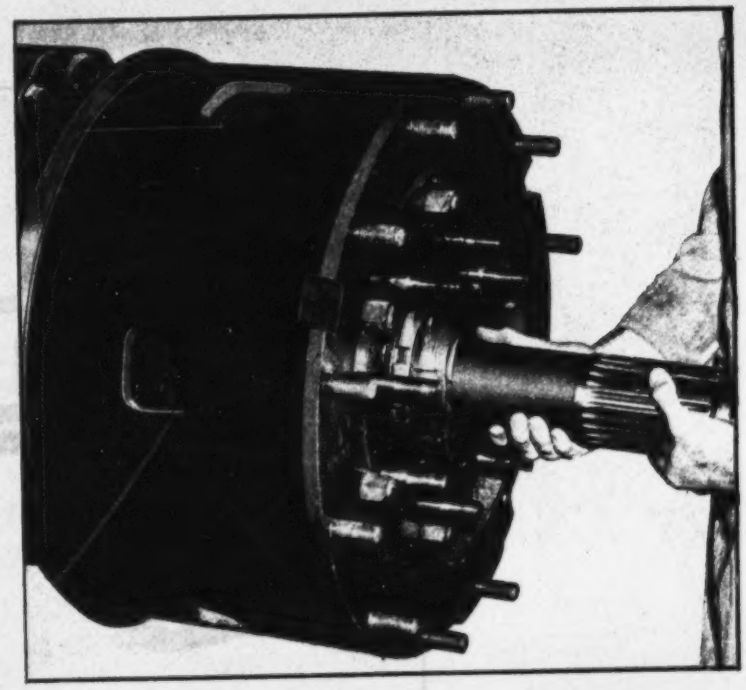


Fig. 6 Removal of the outer axle shaft.

Units having the planetary outboard (encased in the drive wheel) use only one axle shaft. In this case, remove the driving flange cover plate and, with a suitable hook tool, reach in and withdraw the sun pinion, bringing with it the axle shaft. All that is necessary is to bring the axle shaft out of engagement with the differential side gear. See Figure 8.

Remove the drain plug at the bottom of the banjo housing and drain the differential gear lubricant.

Remove the capscrews (bolts) attaching the driveline to the rear companion flange. On some models it may be necessary to remove the snap ring and slack adjuster from the brake control shaft.

Tap the brake shaft toward the wheel JUST ENOUGH TO ALLOW THE DIFFERENTIAL CARRIER TO MOVE FORWARD. If driven too far, the brake shaft will carry the brake operating cam out from between the brake shoe rollers and the brake shoe return spring will cause the shoes to clamp down on the brake shaft, preventing the cam from returning to its proper place.

Remove the nuts which secure the differential carrier in place. Support the carrier with a floor dolly or lift hoist.

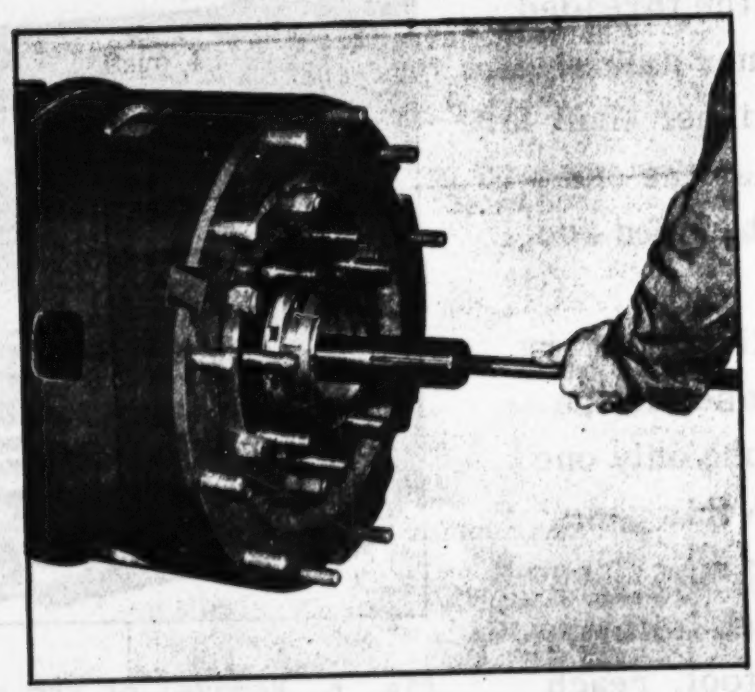


Fig. 7 Removal of inner axle shaft.

With care, so as not to spring the studs or cause damage to the threads, slide the differential carrier forward to free it from the studs. Remove and thoroughly clean the differential carrier, making a visual inspection for wear and damage.

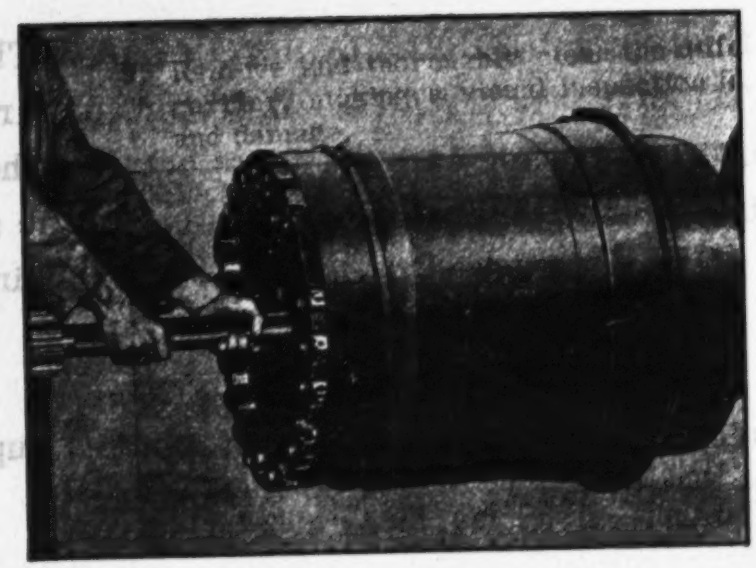
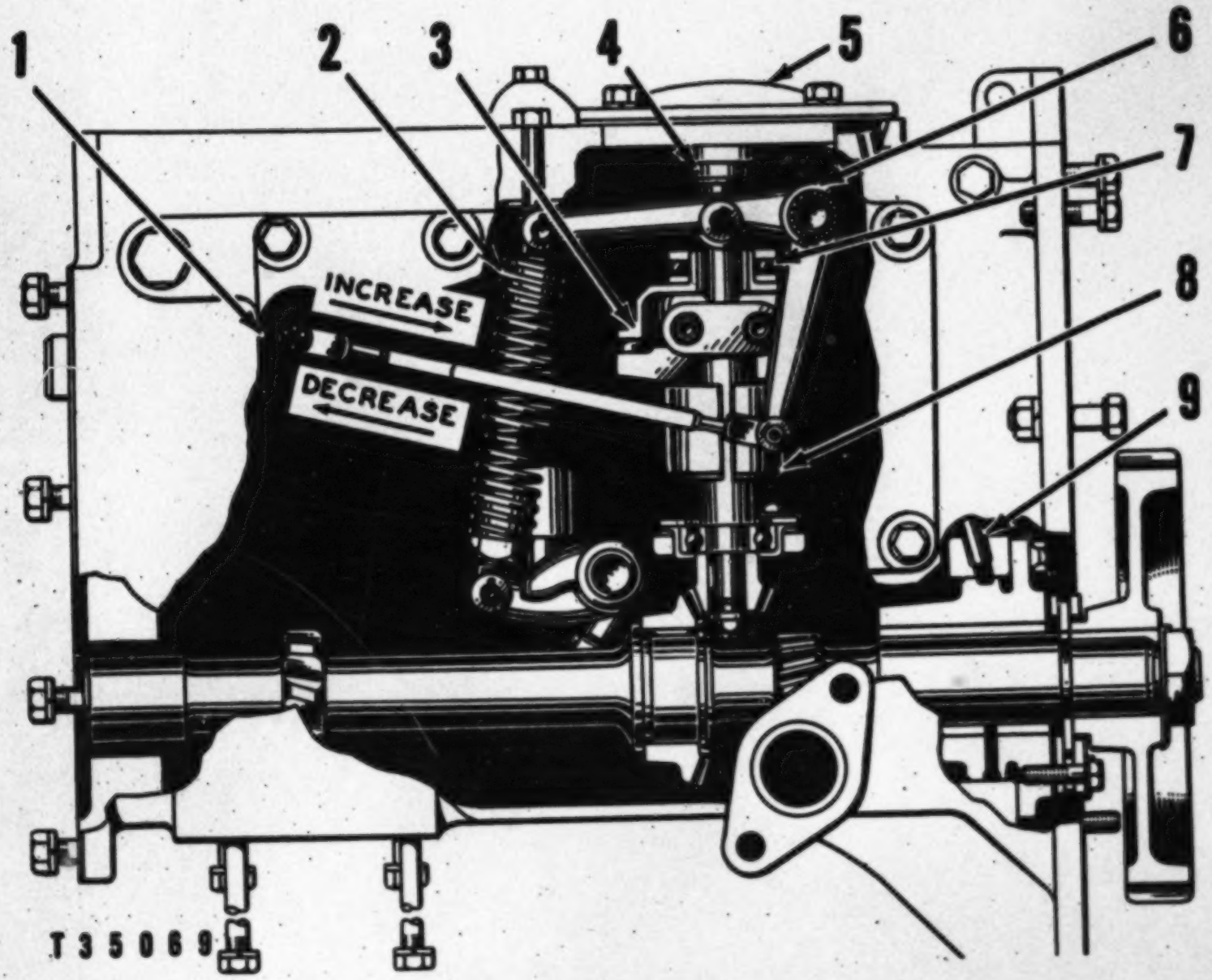


Fig. 8 Pulling shaft out of engagement.



GOVERNOR

1–Rack. 2–Governor spring. 3–Retainer. 4–Upper bearing. 5–Cover. 6–Crank. 7–Thrust bearing. 8–Governor weight. 9–Tube.

Plate I

AM 1-22-23-24D
10/21/66 0

UNDERSTANDING THE CATERPILLAR FUEL SYSTEM

Human Engineering Institute
Minn. State Dept. of Ed. Vocational Education

Press A 1 Check to see that timer is OFF

1

1

This film is designed to supplement units AM 1-22, AM 1-23 and AM 1-24 by highlighting the main points of the CAT fuel systems, reviewing the technology behind the fuel system components, and a few troubleshooting tips to look for when the fuel system fails.

Press A 2

1

2

As we learned in the units, the CAT supply section of the fuel system is not too different from GM and Cummins, with the exception that CAT has_____.

3 A. a larger capacity fuel tank
4 B. some flexible tubing in the fuel system
5 C. a filler cap strainer screen in the supply tank

1

3

You said the CAT supply tank has a larger capacity. This is <u>not</u> true. All systems usually have a fuel tank capacity large enough to last a shift of operation. Try this question again.

Press A 2

1

4

No. Flexible tubing in the fuel system, especially from the fuel tank to the pump, is necessary on all installations because of the vibration factor involved. Try this question again.

Press A 2

1

5

OK. The CAT engine fuel system has one feature as standard equipment that the other two do not and that is the_____.

6 A. filler cap that allows the tank to breathe
7 B. strainer in the tank filler neck
6 C. drain valve in the bottom of the tank

1

6

No. All systems require the fuel tank to be vented so it will not collapse from the vacuum created when the fuel is withdrawn. Also there is <u>always</u> a drain valve at the bottom to drain the moisture and sediment from the tank on all systems. What is unique to CAT is the <u>strainer in the filler neck</u>.

Press A 7

1

7

Another feature that CAT has on its fuel system (and that is typical of systems using the multi-cylinder type fuel pump) is the_____.

8 A. primary fuel filter
9 B. transfer pump
10 C. priming pump

1

8

No. A primary fuel filter is not uncommon on any diesel system. Some installations have as many as six primary filters.

Try this question again.

Press A 7

1

9

No. Some type of pump is necessary to draw the fuel from the tank to the vicinity where it will be metered and pressurized. The priming pump is the answer here.

Press A 10

1

10

OK. Priming pump is correct. This is a feature that saves on the engine starting mechanism when air has contaminated the system through changing filters, etc.

FUEL PUMP GAUGE -- In order for the fuel pressure gauge to perform its function, it would have to be located between_____.

11 A. the fuel tank and the transfer pump
12 B. the transfer pump and the fuel filter housing
13 C. the fuel filter housing and the injection pump

1

11

No. The only pressure that is present between the transfer pump and fuel tank is atmospheric pressure. Try this question again.

Press A 10

1

12

No. You would get a pressure here, but it would defeat the purpose of the gauge, and that is to indicate condition of the filters. It would have to be after the fuel filter housing.

Press A 13

1

13

OK. This gauge indicates proper pressure in the supply side of the fuel system. Remember, lack of the proper indication on this gauge can mean the following:

1. Empty fuel tank
2. Closed shut-off valve at the tank
3. Clogged filter
4. Dirt under the by-pass valve
5. Open vent valve
6. Faulty transfer pump or gauge

Press B 14

1

14

FUEL PUMP -- Something different on the CAT engine, as compared to GM and Cummins, is the multi-cylinder fuel pump. This mechanism is the heart of the CAT fuel system. It is relatively trouble free and is efficient only if it is adjusted correctly. It is like an engine in itself, containing a crankshaft with lobes, pistons and cylinders. It is very much like the Cummins air compressor we studied in past units. It is gear driven, and operates constantly when the engine is running.

Press A 15

1

15

The precision standards to which the CAT fuel pump is manufactured is very much like the_____.

16 A. Cummins PT fuel pump
16 B. GM variable speed governor
17 C. GM injectors

1

16

No. The PT fuel pump and the governor mentioned above are no comparison to the way this CAT fuel pump is manufactured. The only piece of equipment held to these close tolerances is the GM injectors, where lapping of the parts and millionths of an inch tolerances are involved.

Press A 17

1

17

OK. The CAT system is very similar to the GM fuel system, the difference being that the fuel is metered and pressurized in a remote position, not at each injector as the GM is. This means that the CAT has a _____for each cylinder.

18 A. relatively low pressure fuel line
19 B. high pressure fuel line

1

18

No. Remember we said the CAT engine fuel pump meters and pressurizes the fuel at a remote position from the cylinders. This means the lines running from the pump to each cylinder nozzle is a very high pressure line.

Press 19

1

19

OK. Not only are these lines very high pressure lines but all of them are exactly the same length, to_____.

20 A. provide interchangeability with each other
21 B. provide a uniform flow of fuel to each nozzle
20 C. prevent excessive vibration

1

20

No. These lines were not meant to be interchangeable. They come in sets and are numbered for the respective cylinders. Vibration is not a factor here either. The correct answer is: to provide a uniform flow of fuel to each nozzle.

Press A 21

1

21

Now let's go inside the pump and see how the fuel is metered and pressurized.

As we learned in the text, the metering, or the correct amount of fuel to be injected into each nozzle is accomplished in the pump by_____.

23 A. the vertical motion of the plunger
24 B. the rotary motion of the plunger
X C 22

2

22

You answered one or more of the questions in this group incorrectly. Before going on to the inner operation of the CAT fuel pump, review this section. Read carefully and take your time in answering.

Press A 2

2

23

No. The vertical motion of the plunger serves to compress the trapped fuel. The rotary motion of the plunger allows the correct amount of fuel to enter the recess (helix) cut diagonally in the plunger, depending on speed and load of the engine. This is identical to the operation of the _____injectors.

24 A. GM
B. Cummins

You must select the correct answer before you can advance to the next frame.

2

24

OK. The vertical motion compresses the fuel, the rotary motion meters the fuel.

The CAT fuel pump is manufactured to millionths of an inch. Because of this precision_____ _____.

25 A. the pump plungers are interchangeable between barrels of the same pump
26 B. the pump plungers fit only the barrels they were removed from
25 C. Neither A or B above

2

25

No. Remember in our study of the GM injector where the plunger was machined to match the barrel? It is also true in the CAT fuel pump. The fit is so close that the little amount of heat and moisture produced holding a plunger in the fingers will prevent a fit.

Press A 26

2

26

CK. A recess machined around the upper end of the pump plunger forms a helical relief, sometimes called a scroll. A vertical passage connects the recess to the space above the plunger. The plunger will pump only during the time the_____part of the pump is covered.

27 A. outlet
28 B. inlet
27 C. passage

2

27

No. The answer we wanted here is inlet. When the inlet port is uncovered, fuel flows into the recess; it could not be pumping during this time. The outlet (check valve), of course, is at the top where fuel under pressure is forced to the spray nozzles.

Press A 28

2

28

CK. When the helix covers the inlet port from the manifold, fuel is trapped in the scroll cut in the plunger. As the plunger rises, the fuel is put under pressure and injection begins. When the inlet port is again covered, at the top of the stroke _____.

29 A. fuel again flows into the scroll
31 B. fuel flows from the scroll into the manifold
30 C. fuel has all been injected and flow does not occur

2

29

No. When the plunger reaches the top of its stroke, fuel pressure in the scroll is very high. Hence, when the inlet port is uncovered, fuel flows back into the manifold, since pressure there is much less.

Press C 31

2

30

No. More fuel is retained by each plunger than is ever required for the injector spray nozzle during one stroke. Thus the excess fuel still in the scroll after the inlet port is uncovered returns to the fuel manifold.

Press B 31

2

31

CK. Since the plunger has reached the top of its stroke, the fuel pressure within the plunger scroll is much greater than pressure in the manifold. Thus, excess fuel returns to the manifold.

From the study of the CAT fuel pump, we learned that each plunger makes a full stroke each time it is lifted by the cam. Since different amounts of fuel are required because of engine load, there must be a way for more fuel to enter the scroll. This is accomplished by _____.

32 A. raising the pressure in the fuel manifold
33 B. inserting a different check valve
34 C. rotating the plunger

2

32

No. The pressure in the fuel manifold is held constant by the supply pump. Besides, even if the pressure were raised, the scroll would allow only a certain amount of fuel to enter. Try this question again.

Press A 31

2

33

No. This check valve is fixed according to the pump size. The answer we wanted here was: rotating the plunger. Let's see how this would allow more fuel to enter the scroll.

Press A 34

2

34

OK. The plunger is rotated within the pump cylinder, allowing more or less area of the scroll to be exposed to the fuel manifold orifice. This rotation is accomplished by a fuel rack (similar to the GM injector) which is connected to the pump governor. As engine load varies, and the throttle is constant, the governor attempts to maintain the required speed. But primarily, the amount of fuel metered by the fuel pump is controlled by the_____.

35 A. fuel rack
36 B. governor
37 C. throttle

2

35

No. The fuel rack only rotates the plungers through action from another source. The answer here is the throttle. However, if the throttle remains constant, the governor compensates for changes in load.

Press A 37

2

36

No. The governor controls the amount of fuel entering the engine only when the throttle is constant. The governor can be overridden by the throttle at safe operating speeds.

Press A 37

2

37

OK. The throttle is primarily the controlling factor in regulating the amounts of fuel entering the spray injectors. Remember, the governor maintains engine speed to meet throttle settings except when the rack limiter, speed limiter and idle rack positions override the governor. More will be said about these components now.

RACK LIMITER -- The CAT engine is equipped with what is called a rack limiter. This component serves much the same purpose as the Aneroid control used on the Cummins diesel. Both controls operate through_____.

38 A. mechanical means
39 B. pressure changes
40 C. spring loaded devices

2

38

No. This control is equipped with a diaphragm that responds to changes in manifold pressure. The purpose of the control is to limit rack movement when there is not enough air to support combustion in relation to the quantity of fuel injected.

Press A 39

2

39

OK. The rack limiter is a pressure operated control that limits fuel rack travel when there is not enough air to support combustion in relation to the quantity of fuel injected.

Press A 40
X C 39 A

2

39A

You have missed one or more questions in this group. Before going on, let's review this data again. Read carefully and take your time in answering the questions.

Press A 26

2

40

On an engine equipped with a rack limiter, such as we have just discussed, if the turbocharger speed increases, the manifold pressure increases. When this happens, the rack limiter is overridden and the governor has full control of the engine. Let's talk now about the governor and its function.

Press A 41

3

41

In Plate I, we see a cutaway view of a D-8 governor which is located in the accessory drive and governor housing. In Plate I, we can see that the governor flyweights move outward from a _____position.

42 A. horizontal
43 B. vertical
42 C. neither A or B

3

42

No. The flyweights are connected to a vertical shaft which is driven through a gear from a horizontal shaft. This shaft in turn is driven from the camshaft gear. The flyweights move out from a vertical position.

Press B 43

3

43

OK. The flyweights revolve around a vertical shaft driven by a bevel gear through a horizontal shaft connected to the camshaft.

The governor spring tension attempts to move the rack in the direction to increase fuel, while the force generated by the governor weights attempts to move the rack in the direction to decrease fuel.

This would mean that when a load on the engine is imposed, the governor weights_____.

46 A. are overridden by spring tension
44 B. move out to decrease fuel
45 C. are overridden by throttle action

3

44

No. When a load is imposed on an engine, rpm is reduced; this slows the revolving shaft and the weights move in. This action allows the spring tension to take over and fuel is increased until a balance between the governor flyweights and the spring tension is again reached.

Press A 46

3

45

This could be true, but would rarely happen because an operator cannot always anticipate changes in load, especially in off-highway CAT powered vehicles. The answer here is: the governor weights are overridden by the spring tension, thus increasing the fuel.

Press A 46

3

46

OK. The load increasing slows the rpm which slows the rotation of the governor flyweights, which allows them to move inward. When this occurs the spring tension takes over and more fuel is injected to the engine. When the rpm is again regained, so is the balance between the spring tension and the force of the governor weights.

Press A 47

3

47

SPEED LIMITER -- Another protective device that CAT engines have is the speed limiter. It does just what the name implies; it limits the rpm under certain conditions. The purpose of this component is to limit engine speed to low idle until enough oil pressure is present. It's location is in the governor housing. With little or no oil pressure in the system, a spring keeps a plunger in front of the arm on the governor control lever. This_____.

48 A. shuts down the engine immediately
50 B. prevents the fuel rack from being moved
49 C. prevents the rack limiter from working

3

48

No. The speed limiter cannot shut down the engine, but it does prevent the engine from reaching rpm's above idling speed. The answer we wanted here is: that in this position, the limiter prevents the fuel rack from moving.

Press A 50

3

49

No. The rack limiter (previously discussed) would have little to do with the fuel rack in this situation because the rack is locked in position. Try this question again.

Press A 47

3

50

OK. Since the governor arm is connected through linkage to the fuel rack and the governor arm is locked in place by the speed limiter, no movement of the fuel rack is possible.

Fuel System Maintenance Tips -- The CAT fuel system is relatively trouble free if the following maintenance and inspection procedures are performed.

1. Use clean fuel - keep out dirt
2. Change fuel filters when pressure gauge reads 'out', (engine must be running).
3. Always drain and flush filter housing before installing new fuel filters.
4. Drain sediment and water from filter housing and fuel tank regularly.

Press A 50-1

3

50-1

A good thing to do at the end of each shift is_____.

51 A. drain all fuel out of the fuel tank
52 B. fill the fuel tank
51 C. inspect fuel tank breathe cap for condensation

3

51

No. The answer we want here is: fill the fuel tank at the end of each shift. This prevents condensation from collecting within the tank and diluting the fuel.

Press A 52

3

52

OK. A half-full fuel tank, if allowed to stand for any length of time, and under certain conditions, will cause condensation to form -- which dilutes the fuel.

Let's move on to some basic questions about the voltage regulator and alternator. This portion of the film will consist of questions about these components to test your knowledge.

Press A 54

XC 53

4

53

You have missed one or more questions in this group. Before moving to new material you will be given the chance to review. Read carefully and think before answering the questions.

Press A 41

4

54

The GENERATOR or ALTERNATOR is a device used on vehicles for the sole purpose of_____ _____.

55 A. supplying alternating current to the electrical charging system

57 B. changing mechanical energy into electrical energy

56 C. supply current to the starting motors

4

55

No. Vehicles using batteries are not able to use alternating current because current can flow in only one direction through a battery. The alternating current must be changed to direct current. Try this question again.

Press A 54

4

56

No. The battery supplies current for the starting motor. The alternator/generator recharges the battery. The answer we want here is that the alternator/generator changes mechanical energy into electrical energy.

Press B 57

4

57

OK. Mechanical energy is changed into electrical energy by turning the internal parts of the alternator/generator. Most alternator/generators are belt driven.

Alternators have proven to be more efficient than generators because they are capable of producing more current, even at low speeds.

REGULATORS are needed for vehicle AC and DC generators to_____.

58 A. maintain maximum current output

59 B. prevent them from producing excessive current

4

58

No. If maximum current were produced constantly, the generators and alternators would burn up from the heat. The answer we want here is: the regulator prevents them from producing excessive current.

Press A 59

4

59

Correct. Excessive voltage and current in either an AC or DC generator would cause them to burn up. Regulation is accomplished by limiting the amount of current flowing in the generator field windings. As mentioned in the text, we will not attempt to go too deeply into basic electricity at this time; this subject will be covered much more thoroughly later on.

For the remainder of this lesson, we will be reviewing the CAT fuel system.

Press A 60

4

60

The priming pump on a CAT fuel supply system is used for the sole purpose of_____ _____.

61 A. drawing fuel from the supply tank

63 B. saving the starting engine from excessive cranking

62 C. metering the correct amount of fuel

4

61

Not quite. You are partly correct. It <u>does</u> draw fuel from the supply tank but that is not its purpose. The priming pump is used to save the starting engine or other starting devices from laboring long periods of time when there is air in the system.

Press A 63

4

62

No. The priming pump does not meter the fuel; this is done by the fuel pump. The answer here is that the priming pump is a feature on CAT engines used to save the starting device from laboring over a long period of time when air has gotten into the system.

Press A 63

4

63

OK. The priming pump is used for clearing the fuel supply system of air that has been entrapped in the lines. Air can get into the system by changing filters for instance. This device saves the starting mechanism from laboring over long periods of time trying to clear out this air.

The function of the fuel pressure gauge is to _____.

64 A. shows that the fuel tank is properly pressurized
65 B. show that the fuel pump is operating
66 C. indicate to the operator that the filters are working

4

64

No. The only pressure in the fuel tank is atmospheric pressure, which is not indicated. The answer we wanted here is that the fuel pressure gauge, being up stream from the filters will indicate if they are clogged and fuel is not being pumped under the proper pressure.

Press A 66

4

65

No. The fuel pressure gauge would not be an indication that the fuel pump is working properly. It would tell the operator if the fuel supply pump is operating; but the answer we want here is the operator can tell if the filters are clogged because the pressure is low. If fuel pressure is still low after the filters have been changed, then its possible the fuel pump may be faulty.

Press A 66

4

66

OK. Which one of the following conditions in the fuel supply system would also indicate a low reading on this gauge?

67 A. excessive exhaust smoke
69 B. open vent valve
68 C. irregular engine firing

4

67

No. A smoky exhaust can be caused by faulty fuel spray injectors. But it can also be caused by a dirty air cleaner overloading at high altitudes, or badly worn piston rings. The answer we want here is an open vent valve will cause a low reading.

Press A 69

4

68

No. Irregular firing can be caused by faulty fuel spray injectors. It can also be caused by the burning of excessive lubricating oil escaping past worn piston rings, or new rings which have not become fully seated. The answer we wanted here is that an open vent valve will cause a low gauge reading.

Press A 69

4

69

OK. An open vent valve will cause a low reading on this gauge. So far, we know that clogged filters, an open vent valve, and a faulty transfer pump may be the cause of a low reading. There are still other conditions that can cause a low reading; one of these is stated below; identify it.

70 A. No breather cap on the fuel tank
71 B. Dirty air cleaner
72 C. Empty fuel tank

4

70

No. The absence of a fuel tank breather cap would only increase the probability of getting dirt into the fuel tank. Try this question again.

Press A 69

4

71

No. A dirty air cleaner would be starving the engine for air, making combustion poor. It would not affect the fuel pressure gauge. Try this question again.

Press A 69

4

72

OK. Now let's review the injection part of the CAT fuel system which consists of the injection pump housing, fuel manifold, injection pumps, lines, injection spray nozzles and the precombustion chambers.

Checking fuel injection equipment -- Before removing major components of the fuel injection equipment for testing, there is a simple procedure to follow to determine which cylinder is causing difficulty. Let's look at this simple check.

Press A 73

4

73

With the engine running at the speed which makes the defect most noticeable, momentarily loosen the fuel line nut on the injection pump to sufficiently cut out one cylinder. Repeat this procedure for the number of cylinders the engine has. If one is found where loosening makes no difference in the irregular operation of the engine, or causes puffing or black smoke at the exhaust to cease, it is likely that the pump and nozzle for that cylinder need be tested.

Press A 74

4

74

The most likely causes for faulty fuel injection performance are:

1. air in the fuel system
2. low fuel supply
3. water in the fuel
4. clogged fuel filter
5. insufficient fuel transfer pump pressure

See the CAT maintenance manual for proper removal and installation instructions for the pump and spray nozzles. It is important to remember that the pump housing and governor can be removed as a unit or separately.

Press B 75

4

75

Let's review. To meet the changes in engine load, the volume of fuel injected is varied by rotation of the (1). This changes the position of the (2) in relation to the inlet port.

76 A. (1) pump camshaft
(2) injection spray nozzle

77 B. (1) governor flyweights
(2) pump plunger

78 C. (1) pump plunger
(2) scroll

4

76

No. Rotation of the pump camshaft moves the plungers up and down in the barrels of the pump. Also the spray nozzle position cannot be changed, they are fixed and fuel entering the nozzle cannot be changed at this point of injection. Try this question again.

Press A 75

4

77

True, the governor flyweights do have an effect on the amount of fuel that is injected. However, the mechanism that actually changes the volume of fuel is the rotation of the pump plunger. This as you recall opens more scroll area to the inlet port.

Press A 78

4

78

OK. The governor flyweights do have an indirect effect on the amount of fuel that is injected, but the real cause is rotation of the pump plungers, opening more scroll area to allow more fuel to enter when load increases.

As the governor flyweights move in, it is usually an indication that ___(1)___ and the ___(2)___ will move in such a position as to ___(3)___ the fuel.

81 A. (1) a load has been put on the engine, (2) fuel rack, (3) increase

79 B. (1) the throttle has overridden the governor, (2) governor springs, (3) decrease

OC. (1) governor springs have overridden the flyweights, (2) fuel rack, (3) shut-off

4

79

No. The throttle overriding the governor would not cause the flyweights to move in. However, it is true that the governor springs would call for more fuel should the flyweights move in, indicating that a load had been imposed on the engine. This being so, the fuel rack would then move to a position to increase the fuel.

Press A 81

4

80

You are correct on (1) and (2): the governor springs would override the flyweights when they move in and the fuel rack would move in a position to increase (not decrease) the fuel. This normally happens when a load is imposed on the engine.

Press A 81

4

81

OK. Now you're getting it. That completes this lesson on the CAT fuel system which has covered three text Units, AM 1-22, AM 1-23 and AM 1-24.

Press Rewind

XC -82

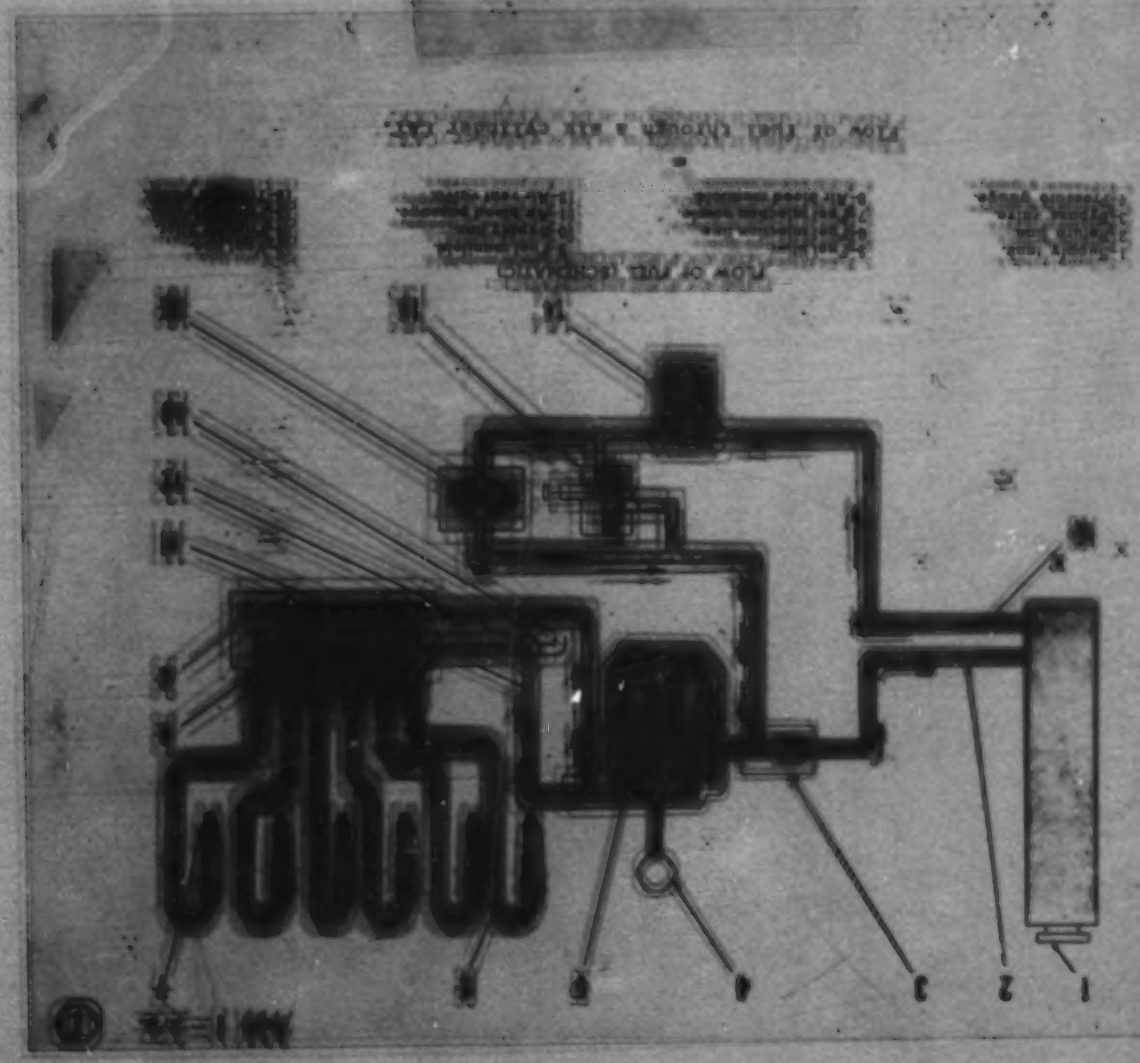
4

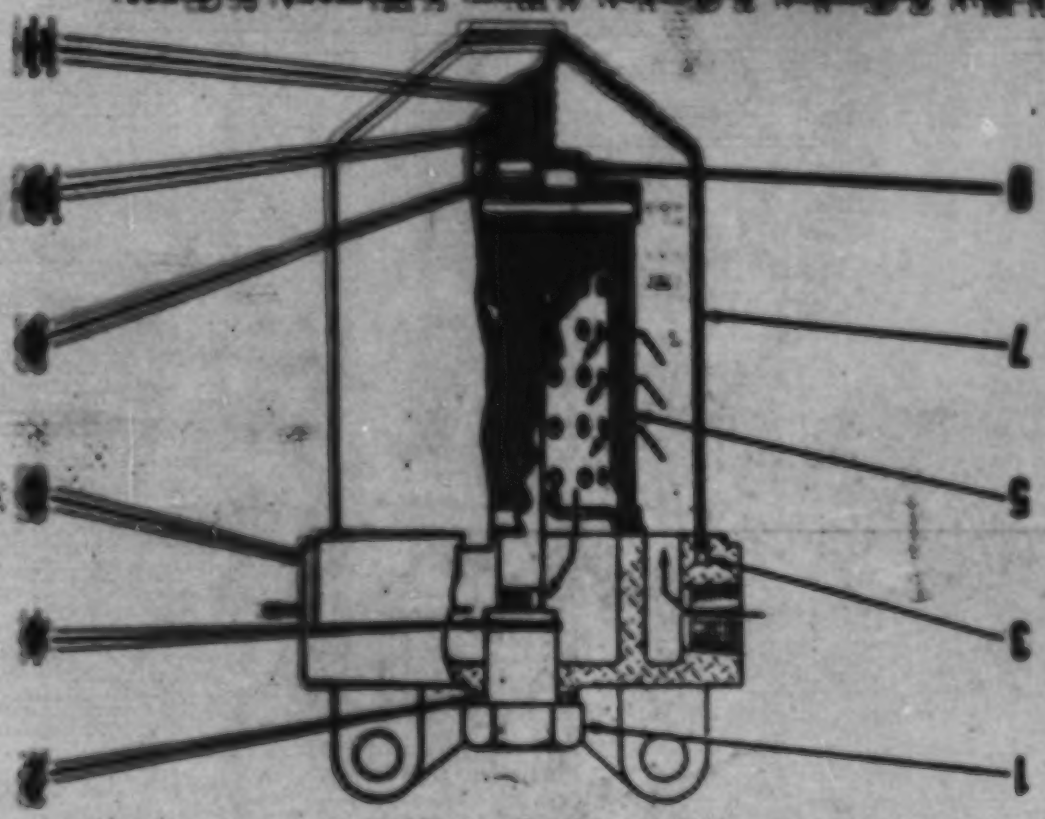
82

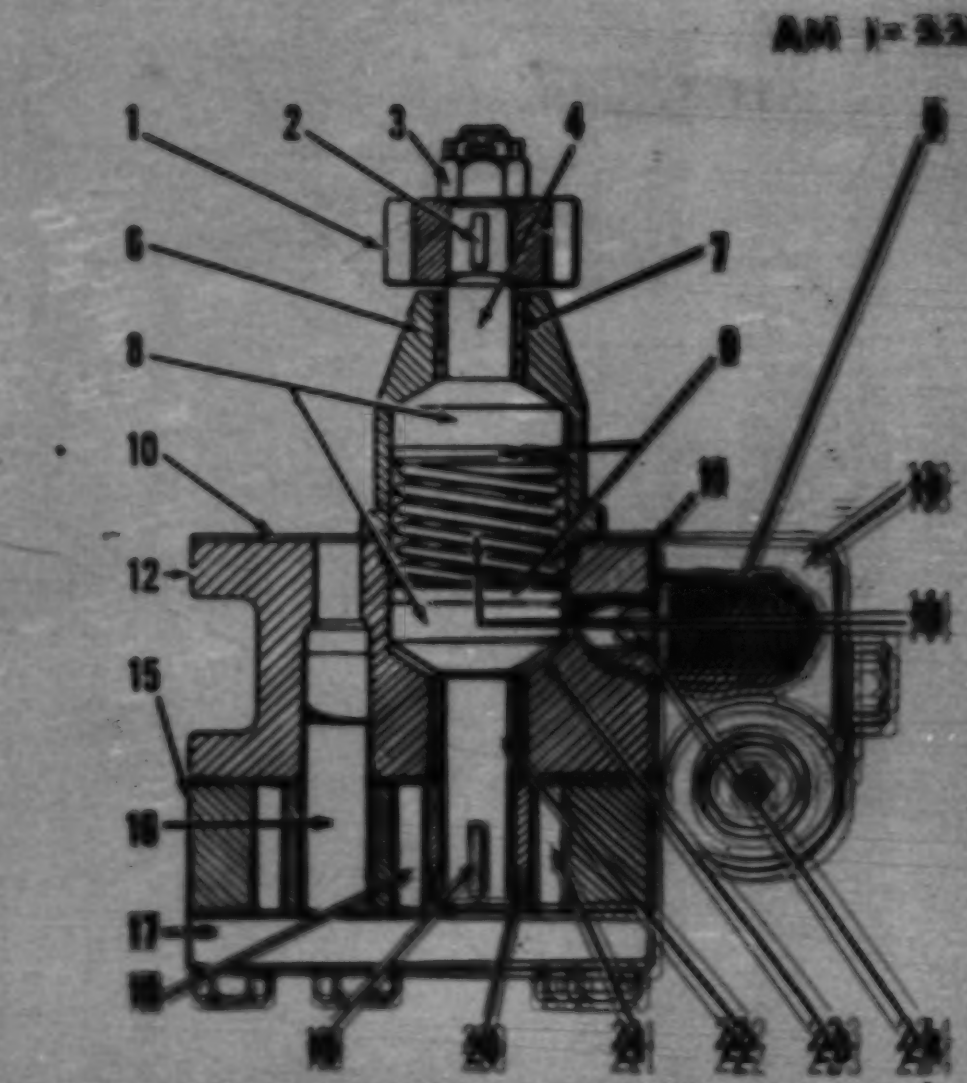
You missed one or more of the questions in this last part of the film. Let's review the last few frames. Read carefully and think before you answer the questions.

Press A 60

4

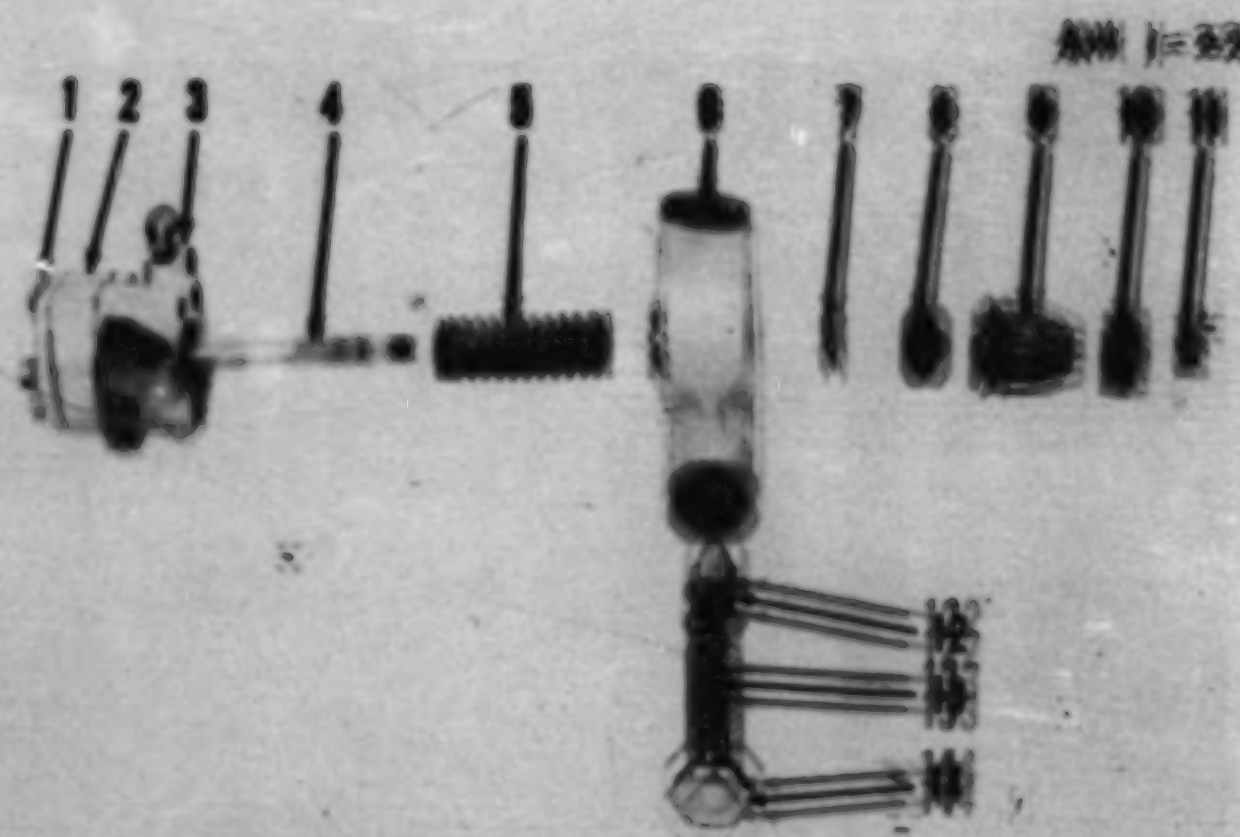






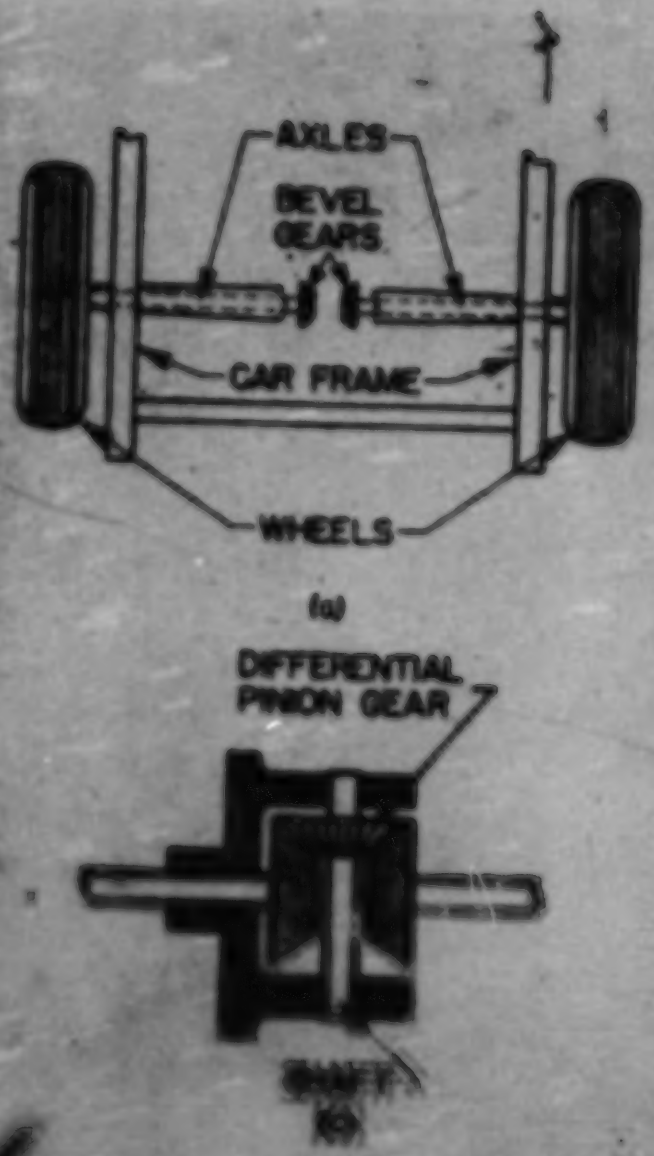
FUEL TRANSFER PUMP

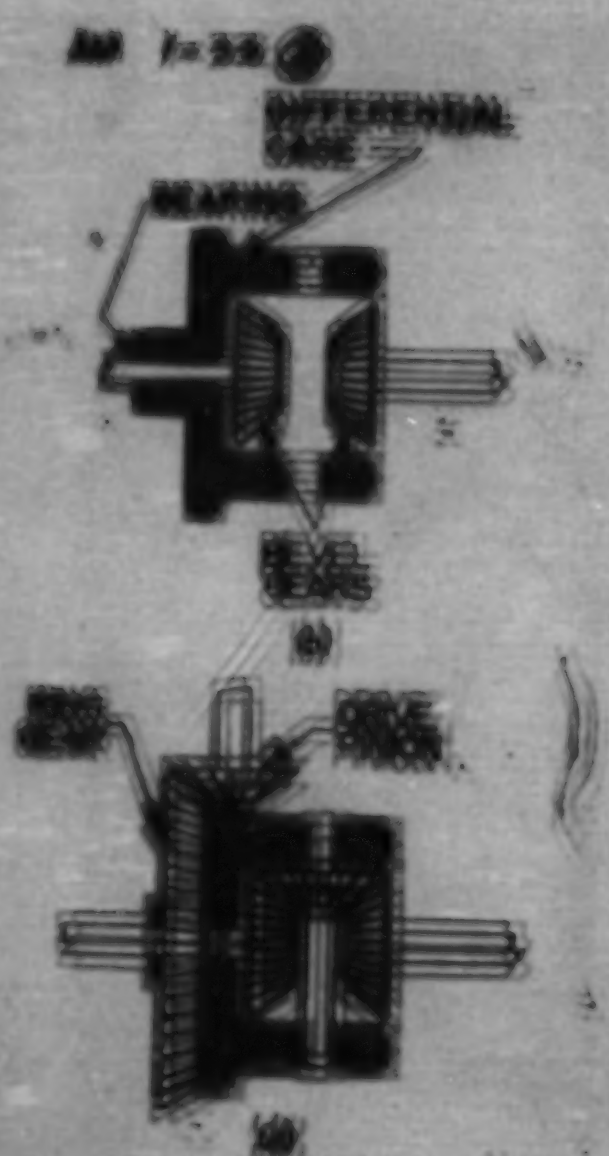
1-Gear. 2-Key. 3-Nut. 4-Shaft. 5-Spring. 6-Seat. 7-Bearing. 8-Seal. 9-Retainer. 10-Gasket. 11-Gasket. 12-Gasket. 13-Adapter. 14-Spring. 15-Body. 16-Idler shaft. 17-Cover. 18-Idler gear. 19-Key. 20-Pin. 21-Drive gear. 22-Bearing. 23-Seal. 24-Plunger.



DISASSEMBLY OF FUEL TRANSFER PUMP

1-Cover, 2-Body, 3-Bracket assembly, 4-Shaft, 5-Spring, 6-Body, 7-Retainer, 8-Shaft, 9-Gear assembly, 10-Cover, 11-No. 12-Changing valve, 13-Spring, 14-Changing valve plug.


AXLES
BEVEL GEARS
CAR FRAME
WHEELS
(a)
DIFFERENTIAL PINION GEAR
SHAFT
(c)


DIFFERENTIAL CASE
BEARING
(b)
(d)

INSTRUCTOR'S GUIDE

Title of Unit: I - Maintaining The Fuel System -- Part I
Caterpillar Diesel Engine

II - Understanding The Differential

AM 1-22
8/13/65

OBJECTIVES:

1. To introduce a portion of the Caterpillar diesel engine fuel system (supply section).
2. To explain the importance of a differential, its function, how it operates, and how to remove one from a vehicle.

LEARNING AIDS suggested:

Vu - Cells:	AM 1-22 (1)	Flow of Fuel Through a Six Cylinder CAT
	AM 1-22 (2)	Primary Fuel Filter
	AM 1-22 (3)	CAT Transfer Fuel Pump
	AM 1-22 (4)	Exploded view of Fuel Pump
	AM 1-22 (5)	Rear axle and differential
Models:	Any models of the CAT fuel system components you can bring into class will help. Things such as fuel filters, filter replacement elements, priming pump, transfer pump, etc.	

QUESTIONS FOR DISCUSSION AND GROUP PARTICIPATION:

1. How does the CAT fuel tank differ from the GM or Cummins fuel tank?
2. What two places does the fuel transfer pump maintain pressure? How much pressure?
3. Is all the fuel pumped sent to the filters? Explain.
4. What is the purpose of the air vent valve? Where is it located?
5. If the fuel pressure gauge shows no pressure, what could be wrong? What does a gradual drop mean? A sharp drop?
6. What are the dirt prevention components ahead of the main fuel filters that are characteristic of CAT engines?
7. When would you use the priming pump?
8. On a CAT engine why isn't it necessary to visually check the fuel filters?
9. Why open the drain valve on the fuel supply tank periodically? Explain.
10. Why have a differential on a vehicle?
11. What purpose does the ring gear serve in a differential?